

CLAIMS

What is claimed is:

1 1. An optical attenuator device selectively operable in a
2 non-actuated state and an actuated state, comprising:
3 a waveguide for guiding optical energy, the waveguide
4 having an input section coupled to an intermediate section,
5 said intermediate section having reduced confinement of the
6 optical energy relative to said input section;

7 a thermal source, disposed above said intermediate
8 section, for generating a temperature gradient within a
9 portion of said intermediate section along a vertical axis
10 thereof when said device is in said actuated state, said
11 temperature gradient being sufficient to alter a refractive
12 index profile within said intermediate section such that a
13 portion of said optical energy is deflected downwardly and
14 extracted from said intermediate section.

1 2. The device of claim 1, wherein said intermediate
2 section of said waveguide comprises a core and a cladding
3 bounding said core, said core and cladding having matched
4 thermo-optic coefficients.

1 3. The device of claim 2, wherein said core of said
2 intermediate section has at least one transverse dimension
3 that is significantly larger than a corresponding
4 transverse dimension of a core of said input section.

1 4. The device of claim 3, wherein said intermediate
2 section is coupled to said input section by an adiabatic
3 taper.

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1 5. The device of claim 1, wherein said waveguide further
2 comprises an output section optically coupled to said
3 intermediate section, said output section having increased
4 confinement of the optical energy relative to said
5 intermediate section.

1 6. The device of claim 2, wherein said core is segmented.

1 7. The device of claim 2, wherein said core has a
2 refractive index that is less than a refractive index of a
3 core of said input section and greater than or equal to a
4 refractive index of said cladding.

1 8. The device of claim 7, wherein said refractive index of
2 said core of said intermediate section is equal to said
3 refractive index of said cladding.

1 9. The device of claim 8, wherein said core of said
2 intermediate section and said cladding are formed from the
3 same material.

1 10. The device of claim 1, wherein said portion of said
2 optical energy extracted from said intermediate section is
3 adjusted by varying an electrical control signal applied to
4 said thermal source.

1 11. The device of claim 2, wherein said core and said
2 cladding are formed from polymeric materials.

1 12. A method for controllably removing optical energy from
2 a waveguide, comprising the steps of:

3 (a) directing said optical energy from an input
4 section of said waveguide to an intermediate section of
5 said waveguide, said intermediate section having reduced

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6 confinement of said optical energy relative to said input
7 section; and

8 ~~(b)-generating a vertical temperature gradient within~~
9 said intermediate section sufficient to alter a refractive
10 index profile within said intermediate section such that a
11 portion of said optical energy is deflected downwardly and
12 extracted from said intermediate section.

1 13. An optical attenuator device selectively operable in
2 an actuated state and a non-actuated state, comprising:

3 a core;

4 a lower cladding layer downwardly bounding said core;

5 a first upper cladding sublayer upwardly and laterally
6 bounding said core, wherein said core, said lower cladding
7 layer and said first upper cladding sublayer have matched
8 thermo-optic coefficients;

9 a second upper cladding sublayer upwardly adjacent to
10 said first upper cladding sublayer and having a refractive
11 index substantially lower than the refractive index of said
12 first upper cladding sublayer; and

13 a resistive heater positioned above said core, said
14 resistive heater being configured to generate a thermal
15 gradient within said core, when said attenuator device is
16 in the actuated state, such that the refractive index of a
17 portion of said core is decreased below the refractive
18 index of a portion of said lower cladding layer located
19 downwardly adjacent to said core, causing a portion of the
20 optical energy traveling along said core to be deflected
21 downwardly and extracted from said core.

1 14. The device of claim 13, further comprising a substrate
2 affixed to said lower cladding layer.

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1 15. The device of claim 14, further comprising an adhesion
2 layer interposed between said substrate and said lower
3 cladding layer.

1 16. The device of claim 15 wherein said adhesion layer has
2 a refractive index which is less than the refractive index
3 of said substrate and greater than or equal to the
4 refractive index of said lower cladding layer.

1 17. The device of claim 13, wherein said core, said lower
2 cladding layer, said first upper cladding sublayer, and
3 said second upper cladding sublayer all comprise polymeric
4 materials.

1 18. The device of claim 13, wherein said portion of said
2 optical energy extracted from core is adjusted by varying
3 an electrical control signal applied to said resistive
4 heater.

1 19. The device of claim 13, wherein said resistive heater
2 is capable of generating an average vertical thermal
3 gradient within said core of at least $0.53^{\circ}\text{C}/\mu\text{m}$.

1 20. The device of claim 13, wherein said resistive heater
2 is capable of generating an average vertical thermal
3 gradient within said core of at least $0.67^{\circ}\text{C}/\mu\text{m}$.

1 21. The device of claim 13, wherein said resistive heater
2 is positioned no more than $5\ \mu\text{m}$ above an upper boundary of
3 said core.

1 22. The device of claim 13, wherein the portion of optical
2 energy extracted from said core may be varied in a range
3 between around 0% to around 99.9%.

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- 1 23. An optical attenuator selectively operable in an
2 actuated and a non-actuated state, comprising:
3 a core bound by a cladding, said core and said
4 cladding having matched thermo-optic coefficients, said
5 cladding having an upper surface;
6 a thermal source positioned above said core, said
7 thermal source being configured, when said attenuator is in
8 the actuated state, to generate a thermal gradient within
9 said core such that the refractive index of a portion of
10 said core is decreased below the refractive index of a
11 portion of said cladding located downwardly adjacent to
12 said core, causing a portion of optical energy traveling
13 along said core to be deflected downwardly and extracted
14 from said core; and
15 a cover plate affixed to said upper surface of said
16 cladding and being held in vertically spaced apart relation
17 with respect to said cladding.
- 1 24. The optical attenuator of claim 23, wherein said cover
2 plate is affixed to said cladding by an adhesive applied to
3 areas of said cladding away from said thermal source such
4 that said thermal source is not contacted by either said
5 adhesive or said cover plate.